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RESEARCH AND DEVELOPMENT ITEMS AT THE DEFENSE MAPPING AGENCY (D--ETC(U)
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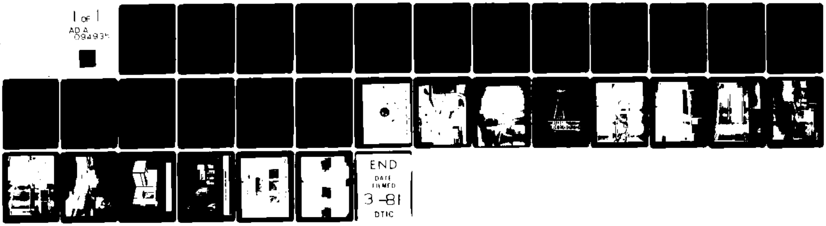

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Satellite Positioning	Photogrammetry	Automated Cartography
Gravity	Cartography	Voice Data Entry
Hydrography	Feature Analysis	Electron Beam Recording
Bathymetry	Feature Extraction	Graphic Arts

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

a. This report covering significant Research and Development (R&D) activities of the Defense Mapping Agency (DMA) is prepared on an annual basis. The following general functional areas are covered in the report:

(1) Geodesy and Geophysics
(2) Hydrography
(3) Elevation Data Collection
(4) Feature Analysis

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BLOCK 19: Map and Chart Reproduction
Sensor Image Simulation
Data Base
Computer Technology
Cartographic Weapons Support
Radar
Data Bank

BLOCK 20:

(5) Automated Cartography
(6) Graphic Arts and Reproduction
(7) Support of the Pershing II Missile
(8) Data Base/Data Bank
(9) Computer Technology

b. Significant activities and developments covered under each of these headings are as follows:

(1) Geodesy and Geophysics. GEOS 3 satellite, World Geodetic System (WGS), inertial technology, astronomic position measurements and DMA's gravity gradiometer program.

(2) Hydrography. Airborne water depth measurement using a multispectral scanner, and shipboard acoustic sensors.

(3) Elevation Data Collection. Improved photogrammetric equipment, rectifiers and digital processing techniques.

(4) Feature Analysis. Description of automating photo interpretation function by introducing artificial and machine intelligence techniques.

(5) Automated Cartography. Raster scanner/plotters, electron beam recorder, voice entry systems and scanning cursors.

(6) Graphic Arts and Reproduction. Laser platemaker, digital color proofing system, direct imaging to paper, and digital image transmission and graphic reproduction.

(7) Support of the Pershing II Missile. Terminal guidance, and sensor image and radar image simulation.

(8) Data Base/Data Bank. Experimental digital interactive facility, remote work processing facilities and cartographic data base.

(9) Computer Technology. Computer architecture and software engineering.

RESEARCH AND DEVELOPMENT ITEMS AT THE

DEFENSE MAPPING AGENCY (DMA)

I. INTRODUCTION

A. This R&D Report is an annual update of the one furnished at the 19-20 July 1979 Five Nations MC&G Directors Conference and covers specific developments that are being delivered to the DMA Production Centers and is also a general treatise covering ongoing and planned DMA areas of research and development.

B. General functional area headings are used to group similar activities.

II. GEODESY AND GEOPHYSICS

A. In the area of Geodesy and Geophysics, the Defense Mapping Agency's activities cover a broad spectrum of disciplines. The radar altimetry data from the GEOS-3 satellite is contributing significantly to the upgrade of the geoidal model over the open ocean areas of the world. With the SEASAT satellite data, refinement of the geoidal model will be further extended in coverage and accuracy. The altimetry data will provide for an improved global gravity model in support of our Post-80 World Geodetic System.

B. DMA is developing systems which would use the NAVSTAR Global Positioning System illustrated in Figure 1. They are continuing efforts in satellite-to-satellite tracking, by developing the "GPSPAC" receiver which will enable high accuracy platform positioning in three dimensions. Also, they are developing a geodetic receiver which will give near real time, accurate point positioning information.

C. The advances in inertial technology have been applied to geodesy and surveying. DMA participated in the development of the Inertial Positioning System (Figure 2), a truck-mounted system which provides latitude, longitude, and elevation over a 40-60Km track to accuracies of 30-50cm. Work continues to improve this measuring capability which may produce an improvement factor of two. Plans are underway to improve our inertial positioning system to include accurate gravity and deflection of the vertical determinations.

D. Astronomic position measurements using the Wild T-4 theodolite (Figure 3) will be automated with the development of a Charge Coupled Device (CCD) eyepiece. This device will eliminate the effect of the observer's personal equation.

E. For the longer term, DMA's role in the gravity gradiometer program may come into play. The gravity gradiometer development programs, currently being conducted by Bell Aerospace, and The Charles Stark Draper Laboratory, are expected to produce fieldable, moving-base gravity gradiometers in the early 1980's. Those instruments should provide greatly improved measurement of the gravity field

for correction and adjustment of field-induced errors to advanced inertial measuring systems.

F. In the field of geomagnetics, DMA is participating in identifying magnetic temporal variations and removing the effects in surveys. The utility of geomagnetic field data is also being assessed.

III. HYDROGRAPHY

A. A contract was let in September 1979 to design, fabricate and test a Hydrographic Airborne Laser Sounder (HALS, Figure 4). The design largely employs currently available technology but there are some developmental aspects, notably in the laser and the signal processing techniques. HALS is expected to be operational in early 1983 and employed in the helicopters carried aboard the Navy coastal survey vessels. Addition of the HALS to the present ship/launch system should increase survey productivity by about 35% under typical conditions.

B. Development of a Hybrid Laser/Multispectral Scanner Airborne Bathymetry System has been initiated. The Naval Coastal Systems Laboratory (NCSL), Panama City, Florida, will develop this system to obtain charting accuracy bathymetry using a multispectral scanner, such as the one aboard the Landsat satellite, in an airplane and depth calibrating it with a pulsed laser. This hydrid system shows much promise for rapid survey of clear, relatively shallow areas. A

computer emulation study is currently in progress to determine the optimum hardware/software configuration necessary to properly handle the expected large data throughput.

C. A number of techniques for exploiting space sensors for bathymetric information are being pursued. Multispectral Scanner data is the most immediately useful in that it measures energy reflected directly from the bottom. Other classes of sensor provide indirect information such as ocean wave spectrum anomalies and thermal structure variations related to subsurface topography. Analog Landsat MSS data is being compared to charts to permit their correction. This process will be automated as much as possible. Algorithms to accurately calculate depths using Landsat data are also being developed. Ultimately, the goal is to automatically intercompare data from a number of bathymetrically optimized sensors.

D. As much of this ocean area to be surveyed is too deep or opaque for the use of electro-optical methods, improved acoustic sensors are being considered. One of the most promising ideas is a side looking obstacle locator which achieves both long range and high resolution with a small transducer using the nonlinear sonar technique. More advanced concepts include rugged, miniaturized multibeam systems, high speed sidescan sonar, and depth measuring sidescan.

IV. ELEVATION DATA COLLECTION

A. Elevation data are an integral part of almost all DMA products. The current trend toward automation of the collection of

elevation data is most evident in the development of the experimental AS-11B-X automated steromapper and the upgrade of the Universal Automatic Compilation Equipment (UNAMACE) (F-16-5). The production version of the AS-11B-X, i.e., the Advanced Compilation Equipment (ACE), along with its supporting data processing system, will provide an order of magnitude improvement in production times for digital terrain elevation data. Currently under design is an advanced interactive editing system to optimize editing of both raw and processed elevation data produced by the ACE and UNAMACE. Research is progressing on a digital stereo compilation capability for the mid 80's.

B. The UNAMACE and ACE rely upon automatic stereo image matching. The Optical Power Spectrum Analyzer (OPSA) is being developed to support these systems by screening photographs before input, with the objective of identifying problem areas prior to processing.

C. Photogrammetric systems are now being designed to accept imagery in either film or digital format. Currently under consideration is the Universal Rectifier which would get away from the specialized electro optical design of current rectifiers and provide a much more flexible capability. Eventually, this technique will be expanded by an ortho rectification technique using a digital terrain matrix.

D. Also being designed are systems which use digital processing techniques to perform automatic point mensuration and stereo compilation.

These aforementioned types of systems, along with complex computational routines, will provide DMA with the capability to meet future production needs.

V. FEATURE ANALYSIS

A. Background

The extraction of MC&G features from film based imagery is an important and time consuming element of the DMA production process. Present systems, intended for near-term use, are aimed at improving this capability while still relying upon the individual to perform most of the photo interpretation. Such systems look at improving the way descriptive information is entered or consolidating the interpretation and digitizing functions. The major focus of the DMA R&D program in this area is to try to automate, as far as possible, the interpretation function by introducing artificial intelligence and machine intelligence techniques.

B. Basic R&D Approach

The approach involves two types of efforts. One type of effort is to develop or identify and test the required techniques. The second type is, at suitable intervals, to take the techniques and integrate them into prototype production systems. Currently, the first two such systems have been identified, although it is the intent

that others would follow. The first of these would be implemented in the mid 80's and would be developed in the early 90's.

C. Techniques Development Efforts

DMA is involved in three general areas of techniques development. These are automated feature extraction, digital image processing, and developing a better man/machine interface. The automated feature extraction is being developed under three efforts. One is involved in taking the image understanding technology developed in the Defense Advanced Research Projects Agency (DARPA) and demonstrating its utility for MC&G problems in an R&D test-bed environment. Second, a part of the Pilot Digital Operations (PDO) is to investigate existing feature extraction capabilities utilizing classical pattern recognition techniques. As part of this effort, seven universities have been tasked with demonstrating the utility of their techniques for the MC&G problem. Third, is an effort to identify areas of shortfall and to further develop to a production posture any promising approaches. The effort in image processing is beginning by focusing on image restoration. The work involving a better man/machine interface begins with implementing a natural language interface and will, in the future, be involved in the area of automatically developing knowledge domain data bases.

D. System Development

It is anticipated that enough positive results will come from the techniques development to allow implementation of the first

system in the mid 80's. This system is called the Interactive Feature Analysis Production System and would be a semiautomated interactive system where most of the work would be under the supervision of the human operator. The operational scenarios would include the case where a routine recognizes when it gets into trouble and asks the operator for help and would also include routines which go to completion and require an operator to examine all the results and make corrections where necessary. For some feature types, all the extraction might be done entirely automated while other feature types might still require total manual feature extraction. The system to be implemented in the early 90's would differ from the first system primarily by its capability to learn from operator actions and thereby continue to improve its automated recognition performance.

VI. AUTOMATED CARTOGRAPHY

A. The black and white raster scanner plotters at DMAAC and DMAHTC (Figure 6) are being modified to increase their capability and operational efficiency when they go into production. A real-time graphic display is being added as well as a capability to scan and plot 16 gray shades. A variable aperture capability to greatly increase the speed of symbol plotting is also being investigated.

B. The five color, plus black, scanner has been installed at DMAHTC and is undergoing operational test and evaluation (Figure 7). In production it will be the large size scanner input to a Sci-Tex Response 250 raster processing system that is also now onsite undergoing operational test and evaluation (Figure 8). The Sci-Tex system

contains a smaller format raster color scanner, two interactive color raster editing stations and a raster plotter.

C. An Electron Beam Recorder was delivered to DMAHTC in May 1980 (Figure 9). It will permit electron beam exposure of both lineal and raster digital data to five micron accuracy on 70 millimeter and 125 x 200 millimeter film. It is currently undergoing test and evalution that will determine its complete production application potential. Possible use includes product output relative to text for the Notice to Mariners publication, Landsat imagery, radar reference scenes, hydrographic chart catalogs and mass storage of hard copy.

D. Use of the voice to record data rather than the fingers for keystroking great volumes of information is becoming a reality in engineering application operations at DMAHTC. A voice digitizer, which has a vocabulary consisting of the numbers one through ten and a limited set of instructions ("erase," punch," etc.), is in use at DMAHTC for recording bathymetric (ocean depth) data (Figure 10). An operator whose voice pattern has been previously stored in the computer's memory bank can have both hands free while reading off bottom-depth soundings. While presently limited to sounding data, the system has been demonstrated to be able to accept other kinds of information, natural features (such as reefs) and manmade object (buoys, piers, wrecks). Another generation of the voice entry system is currently in testing at DMAAC. It is being developed for use in recording feature identifiers in the Digital Landmass Simulation

(DLMS) program. We presently are using only a single station with a limited DLMS feature type vocabulary, but the results of the testing procedure will lead to the design of a multistation system.

E. An Advanced Cartographic Data Digitizing System (ACDDS) has been designed and is now in fabrication. It is the successor to the Lineal Input System that has been in production for six years. It will take advantage of voice entry and scanning cursors to provide a more efficient manual digitizing system.

VII. GRAPHIC ARTS AND REPRODUCTION

A. The major thrust of ongoing and planned R&D activities in the Graphic Arts and Reproduction area is toward development of the capabilities needed to produce graphic products directly from the digital outputs of the increasingly automated cartographic processes.

B. EOCOM Corporation, under contract to the U.S. Army Engineer Topographic Laboratories (ETL), is developing a prototype laser platemaker that will "write" large format (44 x 60 inches) pressplates directly from digital input data (Figure 11).

C. ETL will begin an effort shortly to develop a composite color proofing capability for evaluating and correcting digital map color separation data prior to platemaking operations. This development will be the "digital" replacement for the present manual "watercote" proofing of hardcopy color separate repromat.

D. Research continues into various technologies for direct imaging to paper (or other forms of hardcopy) from on-line digital input. Xerographic, ink-jet, and chromium dioxide processes are being studied. Near-term effort will be focused on development of a capability for limited quantity multicolor reproduction from digital input data. The ultimate long-range objective is development (or exploitation) of a large quantity reproduction capability which may one day replace the present ink and water offset printing presses.

E. DMA is investigating current and emerging technologies for image transmission and graphic reproduction and/or display with the long-range goal of establishing data links between centralized digital MC&G data bases and remote map and chart display (CRT, etc.) and/or reproduction "terminals."

F. Because film based materials will continue to be used in the map and chart production processes for several years, research also continues into various types of nonsilver photographic mediums. A major effort is underway at the Engineer Topographic Laboratories to determine the suitability of emerging electrophotographic imaging materials for use in the production of map and chart quality repromat and also for use directly as press plate material.

VIII. SUPPORT OF THE PERSHING II MISSILE

A. DMA is developing simulated radar images in support of the terminally guided Pershing II surface to surface missile. These

simulated images, which are prepared from optical source material, are stored in the missile prior to launch. As the missile approaches the target location, the simulated image is compared with the live image received by the radar in the nose cone. Differences between the live radar return and the simulated radar image generate inflight corrections which direct the missile to the target. DMA has developed a base plant system, the Pershing Reference Scene System (PRESS), (Figure 12), so that simulated radar reference scenes can be produced for preplanned targets employing digital techniques.

B. Advanced Weapons System Image Simulation

This effort shall be directed towards defining precise parameters/descriptors essential for synthesis of Forward Looking Infra-red (FLIR), Low Light Level TV (L^3TV) and visual sensors including periscope viewing simulations. Additionally, an analysis of present DMA Data Bases will be performed to determine if they can be directly utilized, modified, or if additional descriptors are needed to enable depiction of the above sensors. Once the descriptors are defined then experiments will be conducted to verify the data base improvements. These experiments will keep in mind DMA capability to upgrade the data bases with present and future production equipment and techniques.

C. Sensor Image Simulation

DMA is currently under contract to design and implement a Sensor Image Simulation (SIS) system (Figure 13). The system will

exploit the capabilities of currently available computer display and array processor technology in the development of a comprehensive data base analysis/quality control facility. The system will be delivered to DMA this fall and after acceptance test will provide quality control of DLMS and the Navy Radar Navigation Trainer Device 15-F-12 data bases. SIS will also be capable of transforming these two data bases into sensor image simluations used by DoD. This SIS is programmable, hence, can be used for quality control of new data bases that DMA will produce in the future.

D. Radar Imagery

DMA is developing techniques for future use of radar imagery for MC&G. Specifically, these include analysis to determine the feasibility of installing software on DMA production stereo plotters and comparators for radar imagery, study of the type of data base required to position targets identified in radar imagery and detailed analysis as the use of radar imagery for terrain analysis.

IX. DATA BASE/DATA BANK

A. One of the more important tiers of DMA's digital technology development is the aggregate of tasks related to finding "better ways" to control and to reduce the cost-of-access to very large stores of digital data. Since by definition "better ways" demands a comparative analysis approach, DMA is establishing a digital R&D test-bed to experiment and to evaluate the digital "better ways" of storing,

accessing and delivering MC&G data. Thus, the results of the digital experimental activities will document capability requirements, capability objectives and hardware and software specification for a future DMA Data Base System that will replace the existing DMA Data Base System.

B. At the present time, there are three basic types of ongoing activity interacting in the DMA R&D program: planning, technology development and applications testing. Representative of these activity types are the five current tasks in the DMA R&D program:

1. SYSTEM 90 PROGRAM INTEGRATION SUPPORT - Provide analytical support and planning factors to support development for the DMA System 90.

2. EXPERIMENTAL DIGITAL INTERACTIVE FACILITY - The ETL test facility of DMA, defining standards, developing specifications hardware and software for a future DMA processing, storage and retrieval system would replace the existing production system.

3. EXPERIMENTAL FACILITIES INTEGRATION - Design and implement the integration of DMA's experimental facilities, providing terminal access between all digital R&D facilities.

4. REMOTE WORK PROCESSING FACILITIES (RWPF) - Two RWPF's (Figure 14) will provide onsite capability at DMAAC and DMAHTC for digital image processing experiments, related to Pilot Digital Operations Test, while also serving as remote terminals to ETL, Rome Air Development Center (RADC) and DARPA and other technical segments of the DMA test-bed community.

5. <u>MC&G CARTOGRAPHIC DATA BASE</u> - Develop the data base environment for DMA in the mid to late 80's. This will include the manipulation of product and intermediate data files and might involve the implementation of a specialized data base management system.

C. In the aggregate, therefore, the successful R&D activities of the Data Base/Data Bank technology ties should permit more efficient exchange and more flexible use of MC&G data in R&D and in MC&G production.

X. COMPUTER TECHNOLOGY

A. The thrust of DMA computer R&D is toward applying advances in computer technology to MC&G problems. As the computer industry provides more advances in power for lower cost, DMA is trying to focus on ways to better identify which architectures are more optimum for our own environment, given large volume cartographic data bases. This will be accomplished using automated means of stating and analyzing requirements for systems, followed by automated design tradeoff analysis prior to acquisition of architectures. The use of emulation technology to support this tradeoff is one alternative considered. Of additional interest is establishing how to link available computer components together to form more comprehensive and responsive systems, including networking possibilities. Presently DMA is designing a computer network linking key production subsystems together within each of the DMA Production Centers.

B. There is emphasis on identifying and implementing techniques to improve the quality and correctness of DMA software, as well as the

effectiveness and productivity of the people interacting with computer systems. One preliminary study has identified the elements of a software engineering tool kit and an implementation plan. Several tools are being acquired and evaluated, including the Fortran Automatic Verification System, which is designed to facilitate the testing of FORTRAN programs. A version supporting COBOL programs is in development. Within the near future, software tools supporting the requirements analysis and design phases of software development will be evaluated and acquired. Eventually these tools will be integrated onto some tool bearing host, supporting the universal community of DMA MC&G software developers and users.

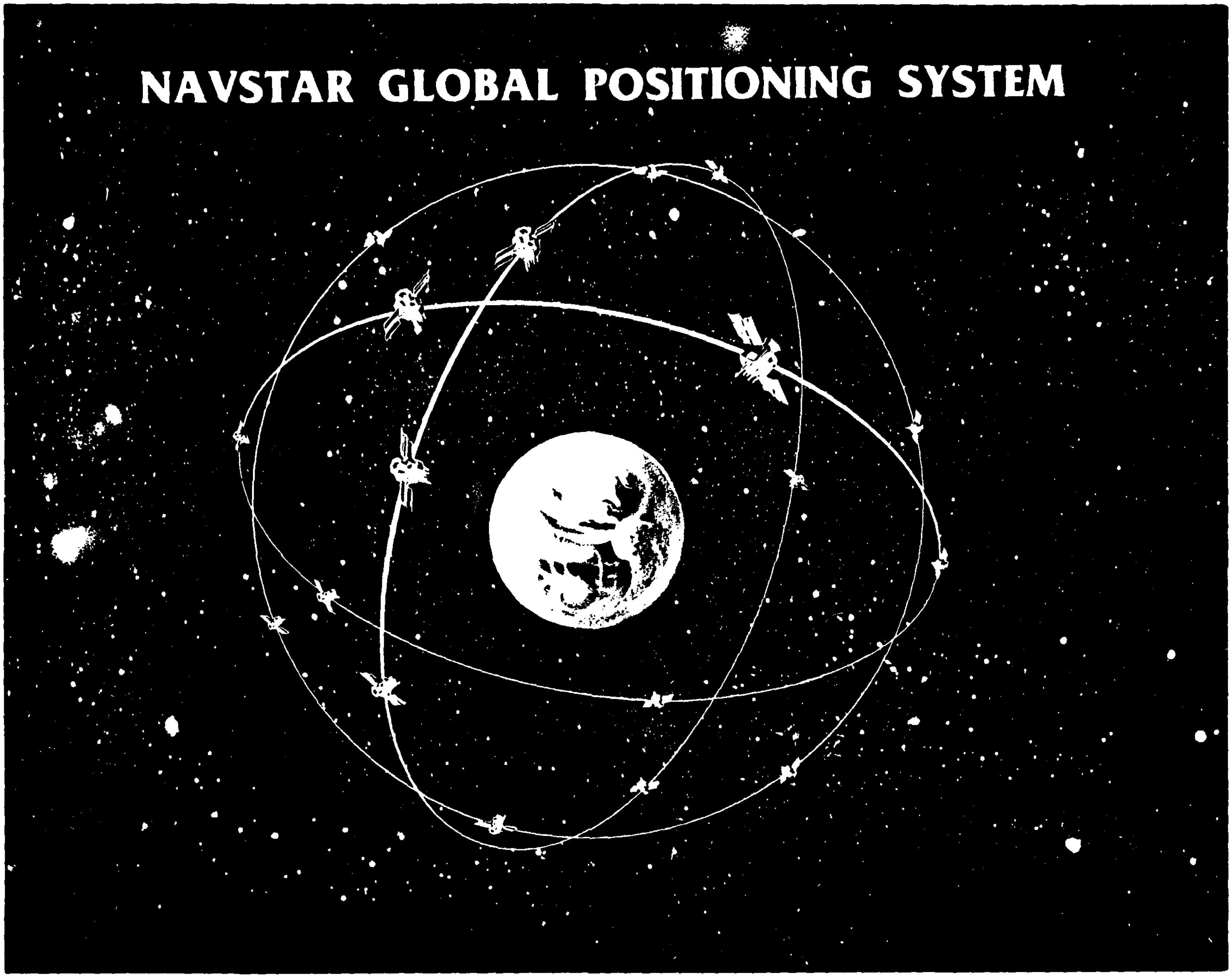

FIGURE 1 NAVSTAR GLOBAL POSITIONING SYSTEM

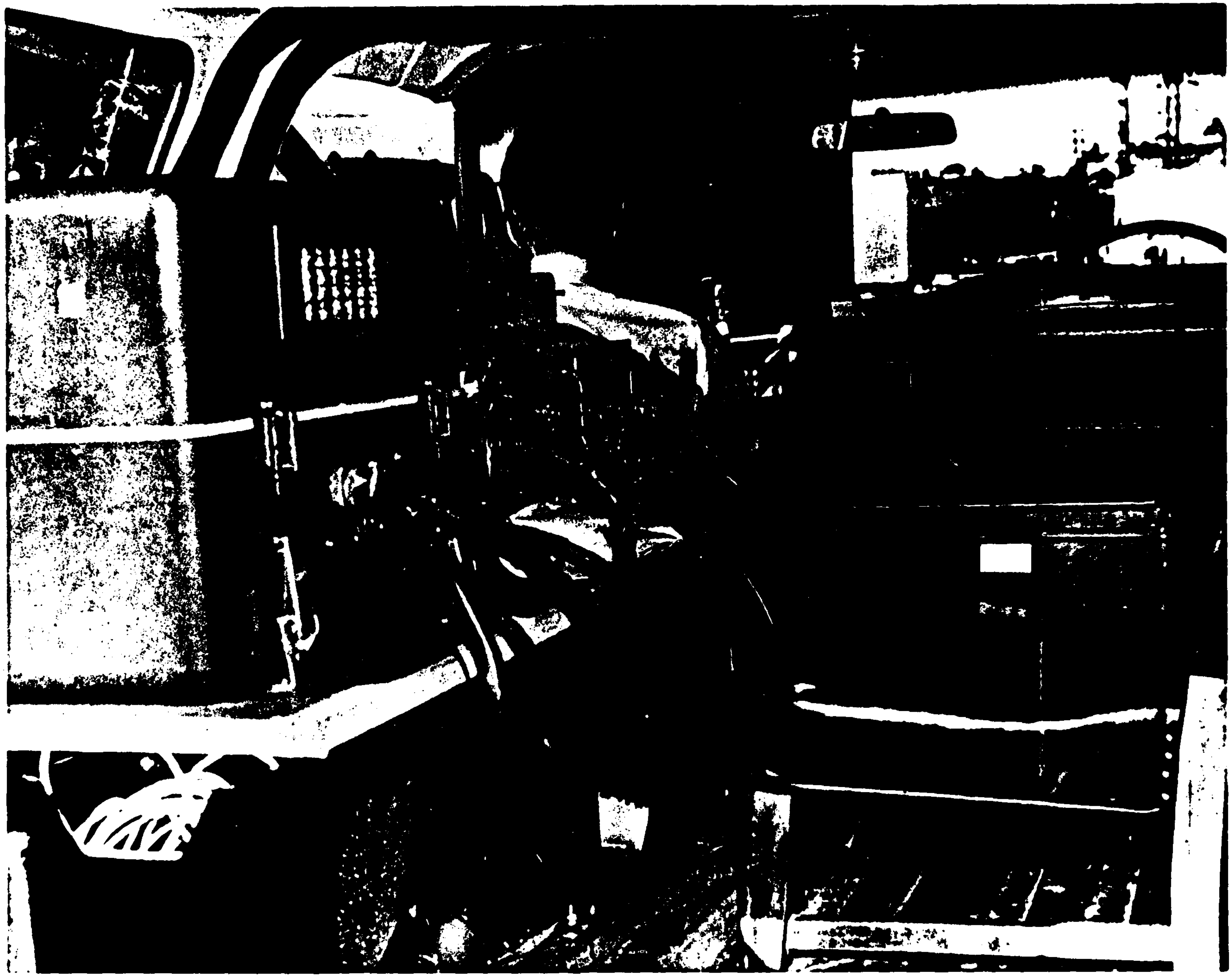

FIGURE [illegible] DMA's IPS mounted in a van

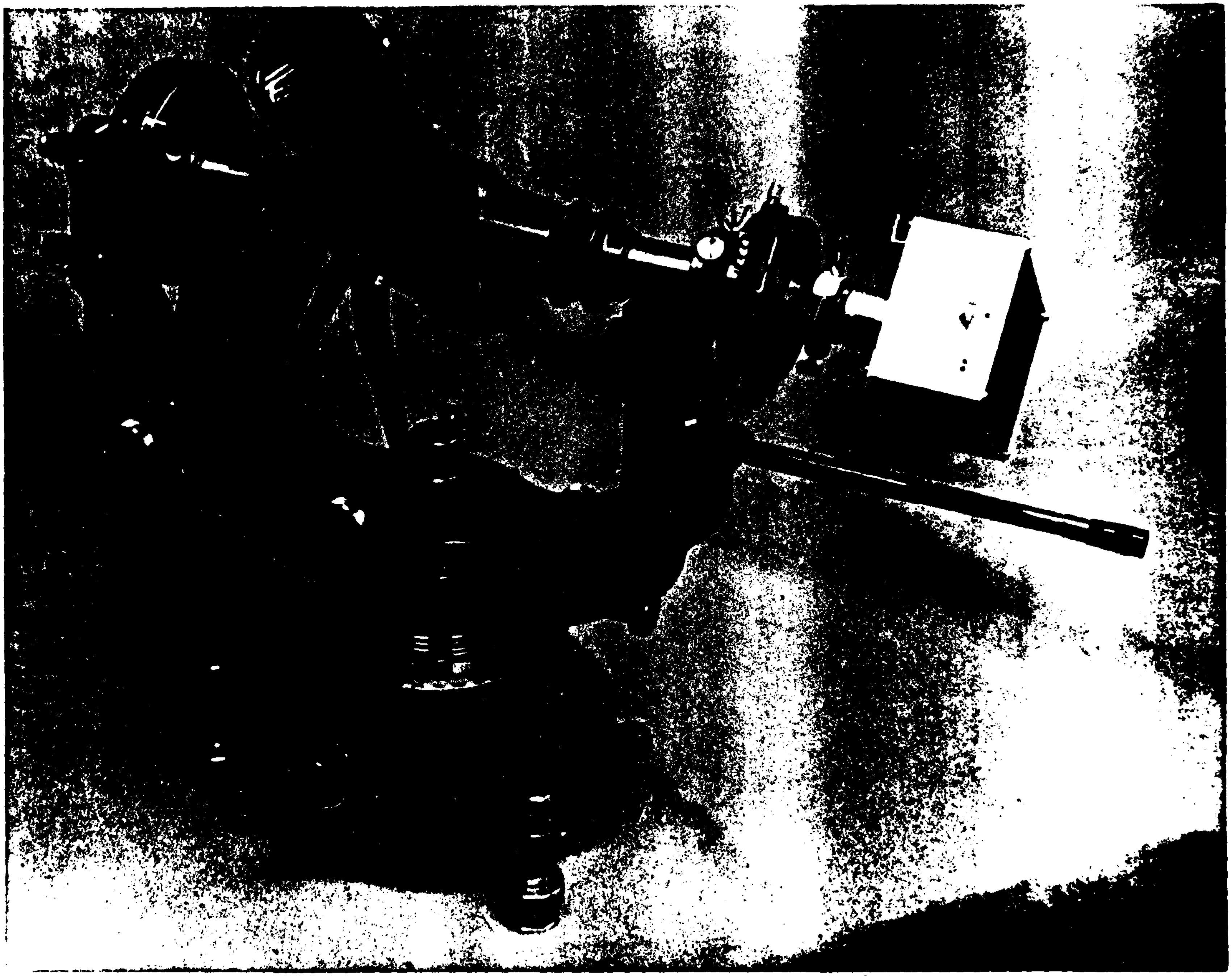

FIGURE 2 WILD T-4 theodolite with the charge coupled device camera

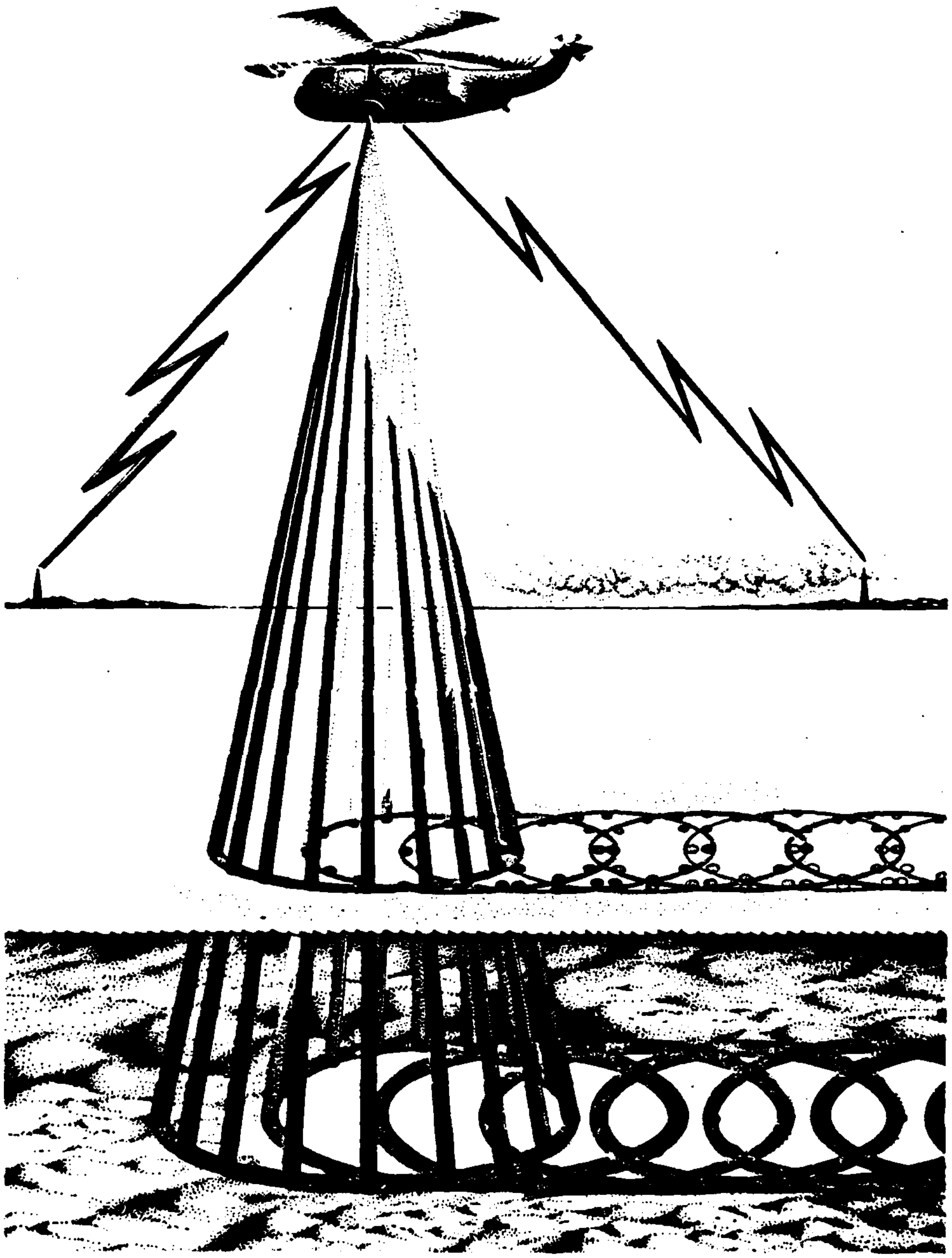

FIGURE 4
HALS concept

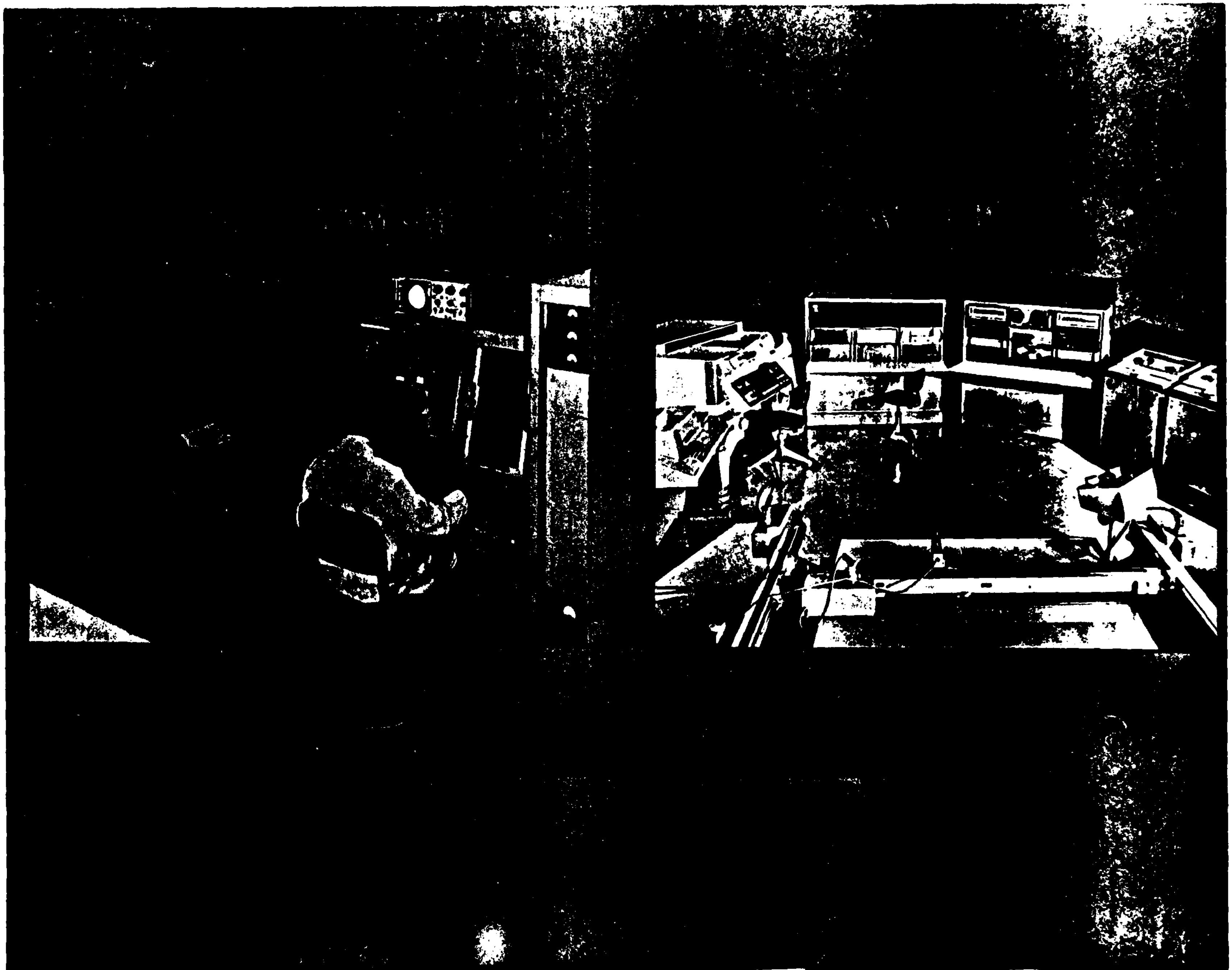

FIGURE 5 Upgrading process capability (UNAMACE & AS-11 B/X)

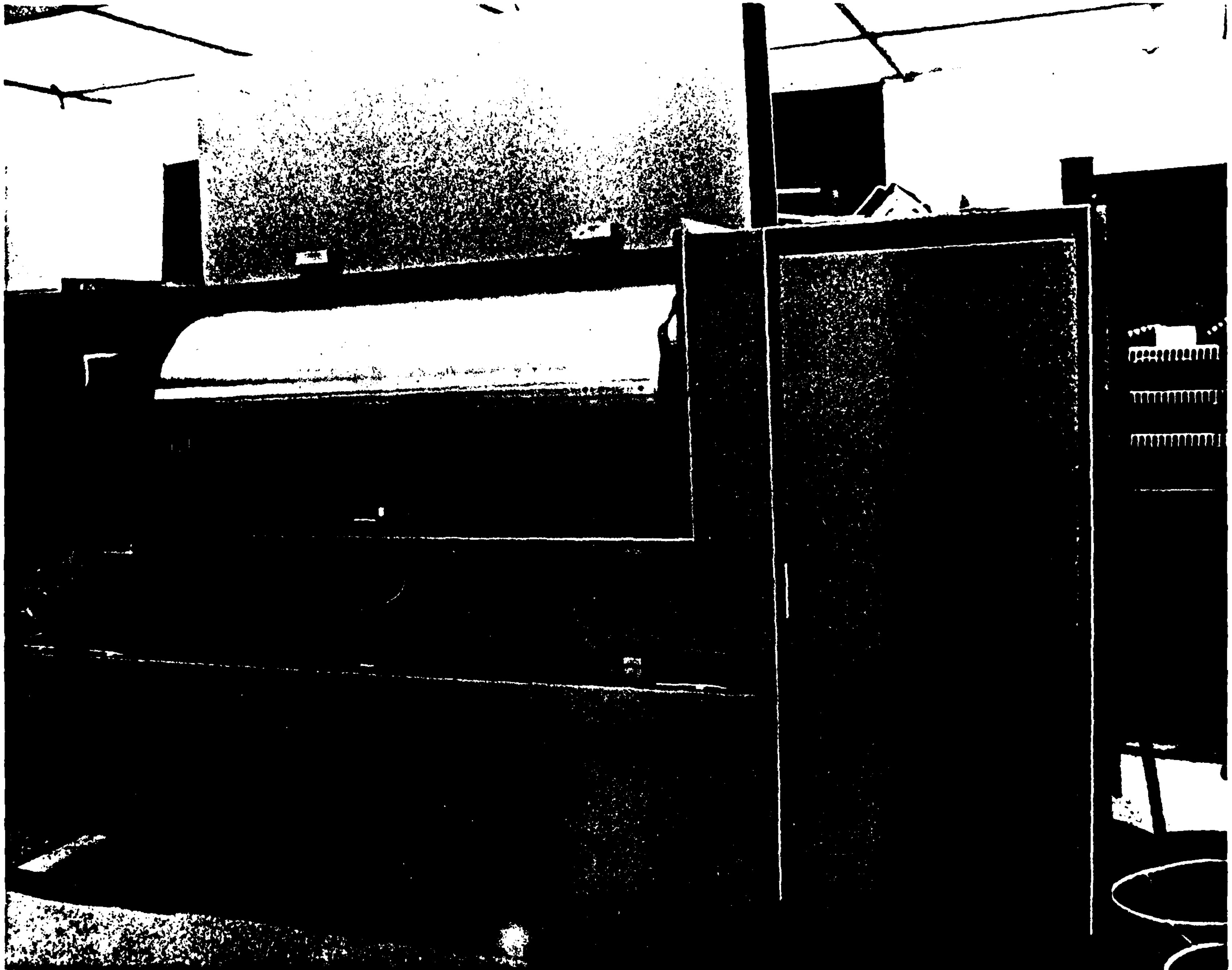

FIGURE 6 Black and White Raster Scanner/Plotter

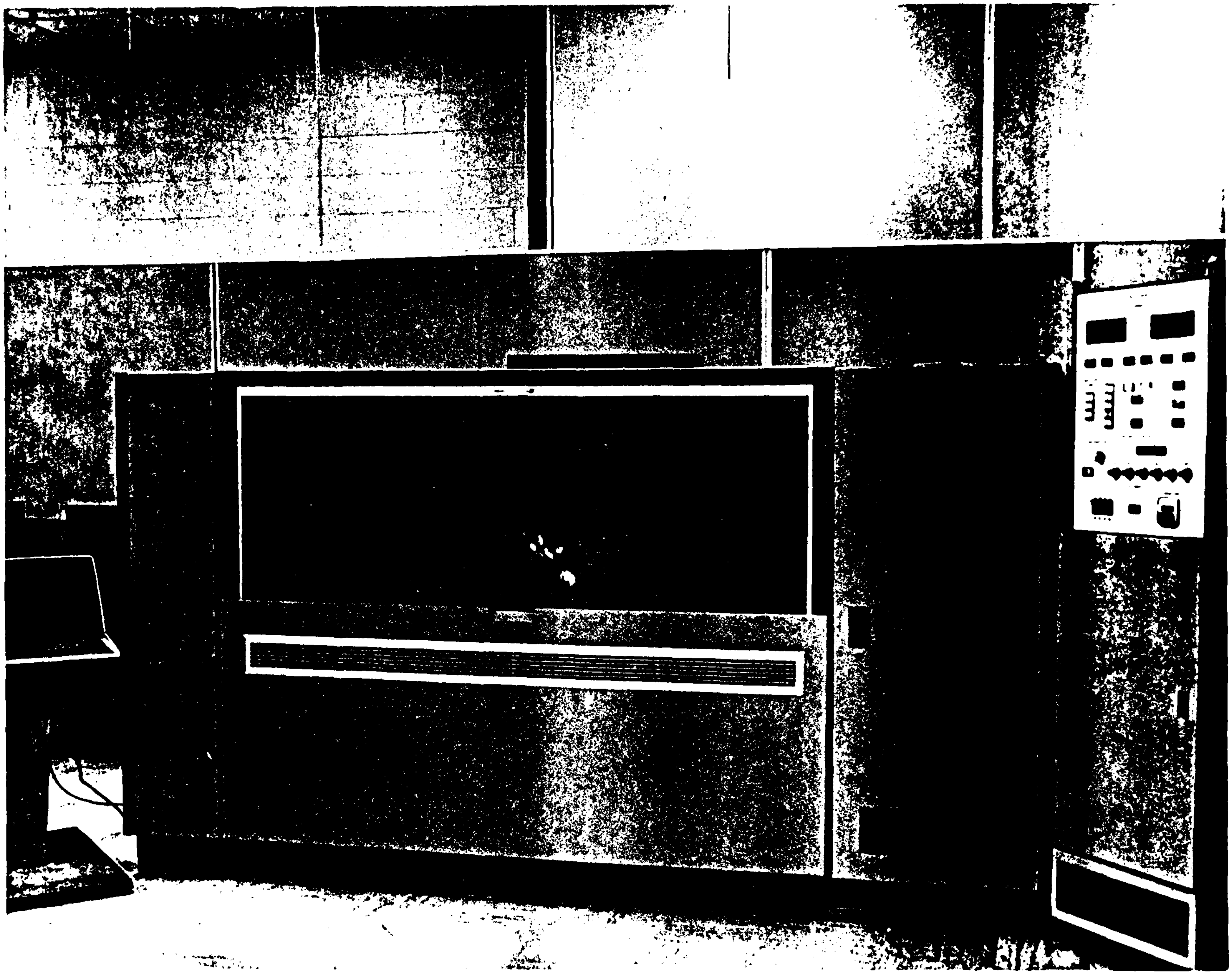

FIGURE 7 Five Color Raster Scanner

FIGURE 8 Raster Processing System

FIGURE 9 Electron Beam Recorder

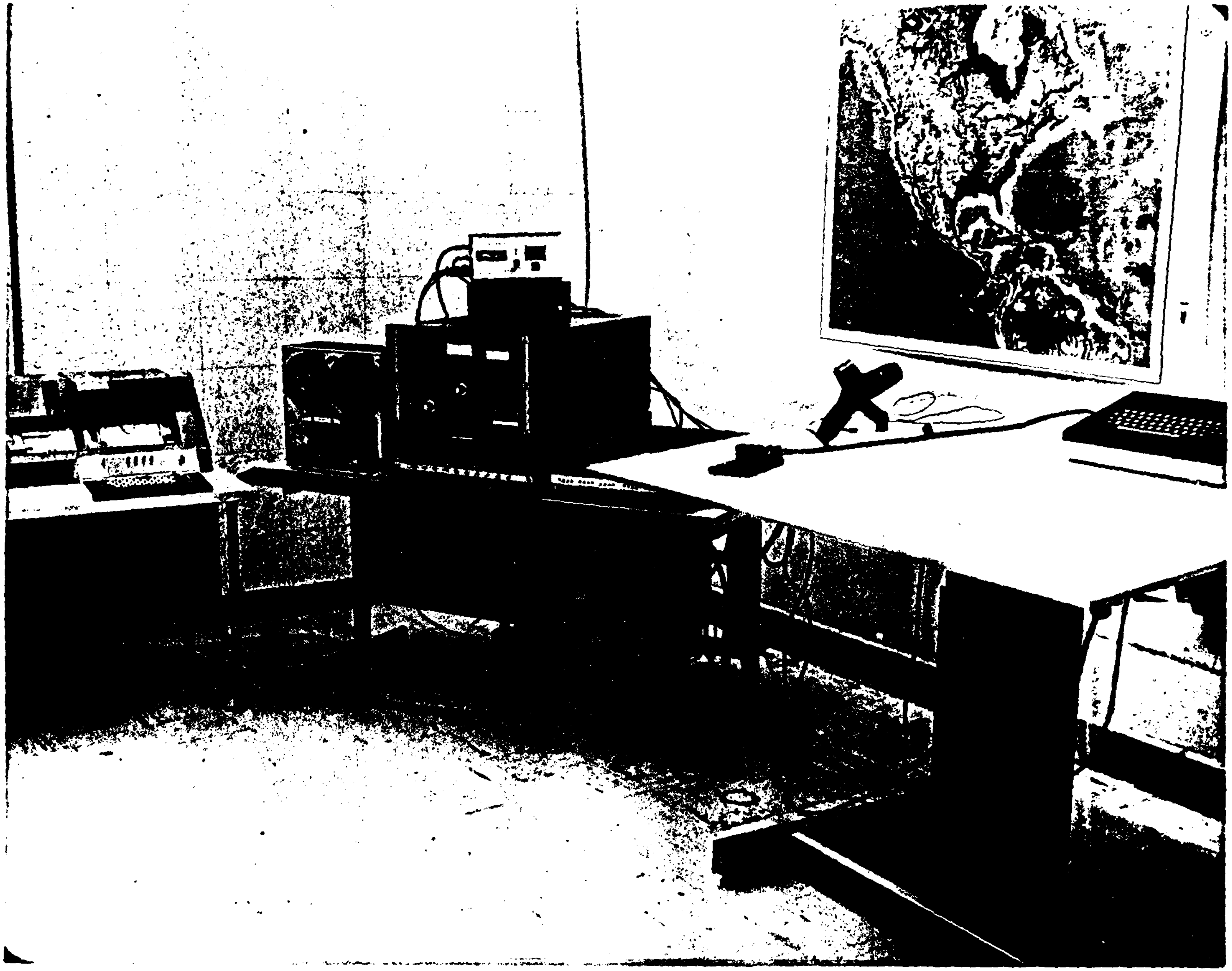

FIGURE 10 Voice Digitizer

FIGURE 11 Digital Laser Platemaker

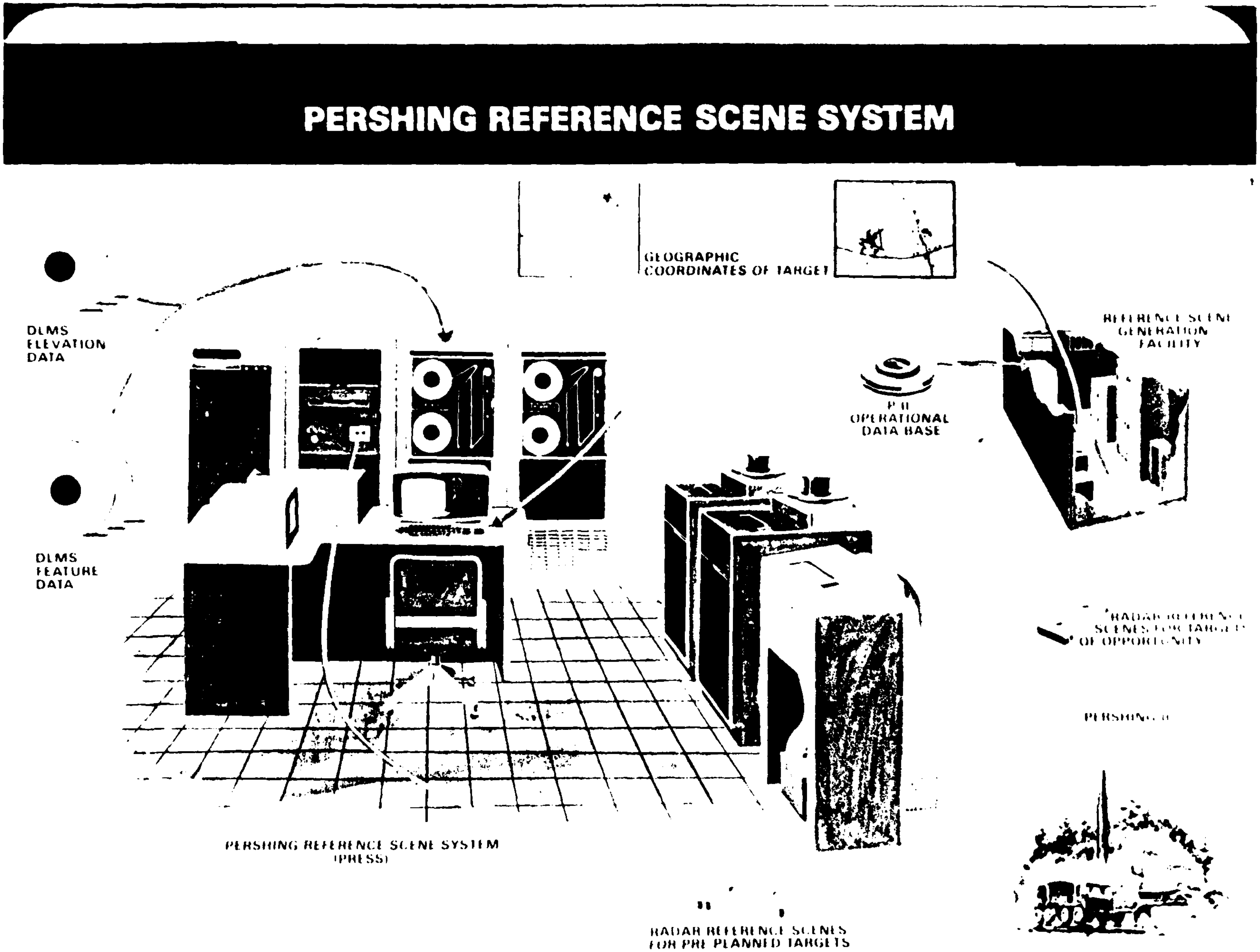

FIGURE 12
Pershing Reference Scene System (PRESS)

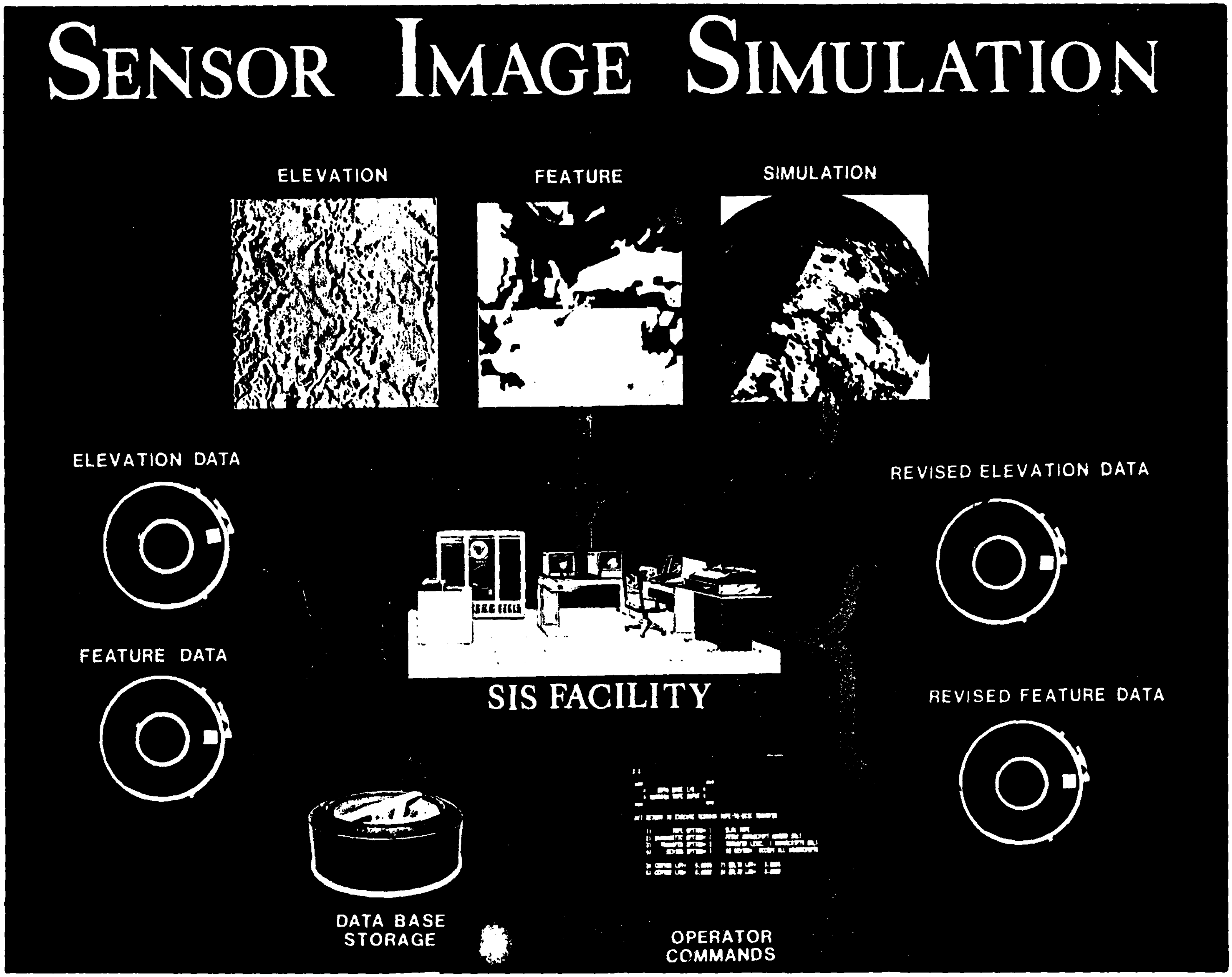

FIGURE 13 Sensor Image Simulation (SIS) System

FIGURE 14 te Work Processing Facility

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